CHAPTER 9
Tides

Overview

- Rhythmic rise and fall of sea level
- Very long and regular shallow-water waves
- Caused by gravitational attraction of Sun, Moon, and Earth

Tide-generating forces

- Barycenter between Moon and Earth
- Mutual orbit due to gravity and motion

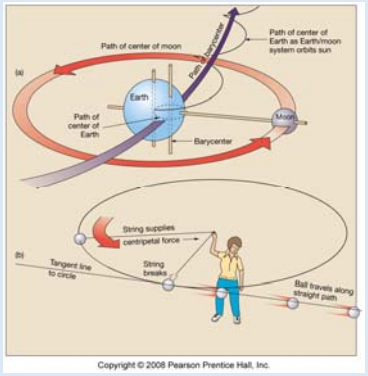


Fig. 9.1

Gravitational forces

- Every particle attracts every other particle
- Gravitational force proportional to product of masses
- Inversely proportional to square of separation distance

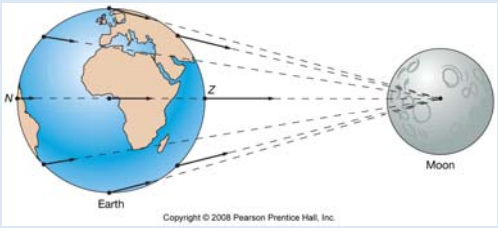


Fig. 9.2

Centripetal force

- Center-seeking force
- Tethers Earth and Moon to each other

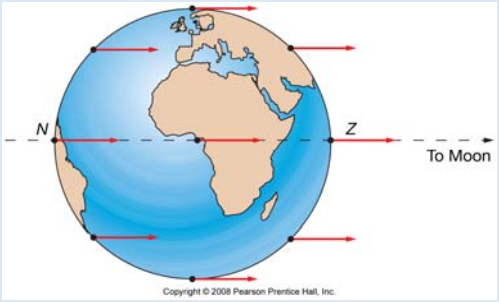


Fig. 9.3

Tide-producing forces

- Resultant forces = differences between centripetal and gravitational forces
- Tide-generating forces are horizontal components

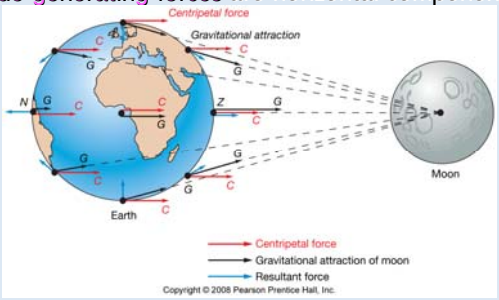


Fig. 9.4

Tidal bulges (lunar)

- Small horizontal forces push seawater into two bulges
- Opposite sides of Earth
- One bulge faces Moon
- Other bulge opposite side Earth

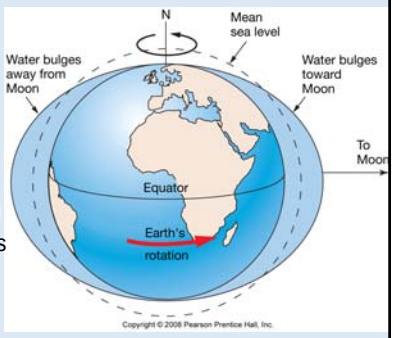


Fig. 9.6

Tidal bulges (lunar)

- Moon closer to Earth so lunar tide-producing force greater than that of Sun
- Ideal Earth covered by ocean
- Two tidal bulges
- Two high tides, 12 hours apart
- High tide, flood tide, seawater moves on shore
- Low tide, ebb tide, seawater moves offshore

Lunar Day

- Moon orbits Earth
- 24 hours 50 minutes for observer to see subsequent Moons directly overhead
- High tides are 12 hours and 25 minutes apart

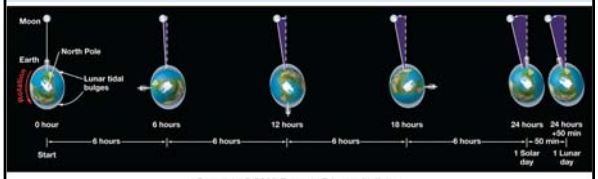


Fig. 9.7

Tidal bulges (solar)

- Similar to lunar bulges but much smaller
- Moon closer to Earth
- New/full moon – tidal range greatest – spring tide
- Quarter moons – tidal range least – neap tide
- Time between spring tides about two weeks

Earth-Moon-Sun positions and spring and neap tides

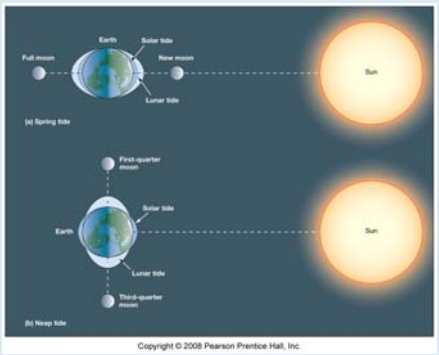
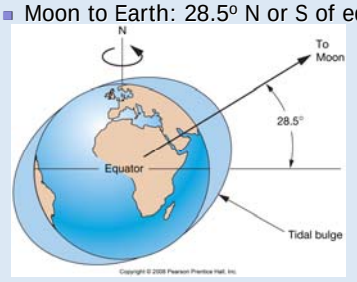


Fig. 9.9

Other complicating factors: declination

- Angular distance Moon or Sun above or below Earth's equator
- Sun to Earth: 23.5º N or S of equator
- Moon to Earth: 28.5º N or S of equator



- Shifts lunar and solar bulges from equator
- Unequal tides

Fig. 9.11

Declination and tides

- Unequal tides (unequal tidal ranges)

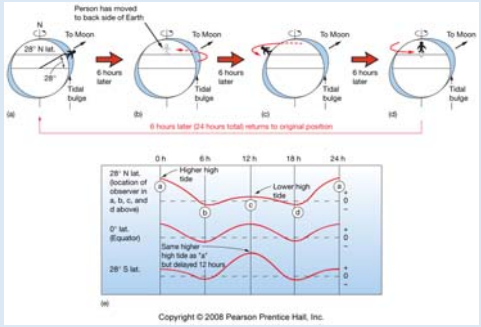


Fig. 9.13

Other complicating factors: elliptical orbits

- Tidal range greatest at perihelion (January) and perigee
- Tidal range least at aphelion (July) and apogee
- Perigee and apogee cycle 27.5 days

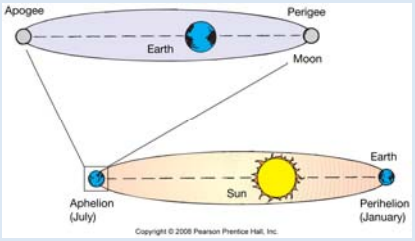


Fig. 9.12

Idealized tide prediction

- Two high tides/two low tides per lunar day
- Six lunar hours between high and low tides

Real tides

- Earth not covered completely by ocean
- Continents and friction with seafloor modify tidal bulges
- Tides are shallow water waves with speed determined by depth of water
- Tidal bulges cannot form (too slow)
- Tidal cells rotate around amphidromic point

Tidal cells in world ocean

- Cotidal lines
- Tide wave rotates once in 12 hours
  - Counterclockwise in Northern Hemisphere

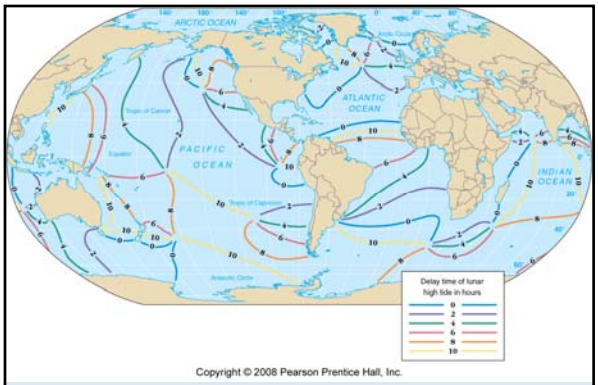


Fig. 9.14

Tidal patterns

- Diurnal
  - One high tide/one low tide per day
- Semidiurnal
  - Two high tides/two low tides per day
  - Tidal range about same
- Mixed
  - Two high tides/two low tides per day
  - Tidal range different
  - Most common

Tides in coastal waters

- Standing waves
  - Tide waves reflected by coast
  - Amplification of tidal range
  - Example, Bay of Fundy maximum tidal range 17 m (56 ft)

Tides in coastal waters

- Tidal bore in low-gradient rivers

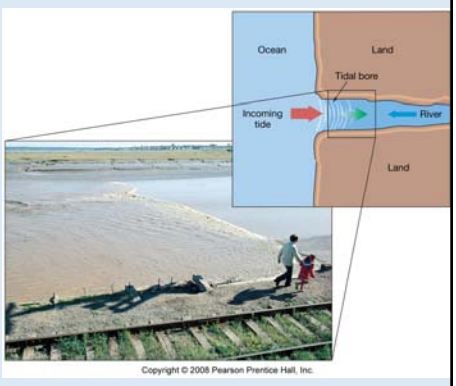


Fig. 9A

Coastal tidal currents

- Reversing current
  - Flood current
  - Ebb current
  - High velocity flow in restricted channels

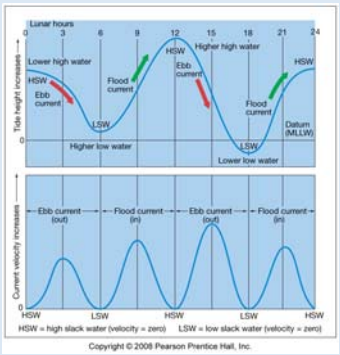


Fig. 9.18

Coastal tidal currents

- Whirlpool
  - Rapidly spinning seawater
  - Restricted channel connecting two basins with different tidal cycles

Fig. 9.19

Tides and marine life

- Tide pools and life
- Grunion spawning

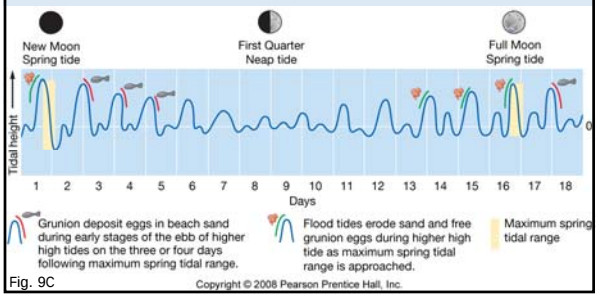


Fig. 9C

Tide-generated power

- Renewable resource
- Does not produce power on demand
- Possible harmful environmental effects

End of CHAPTER 9
Tides

Fig. 9.21